

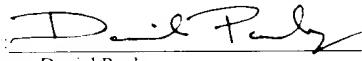


IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Muralidhara et al. Examiner: Ana M. Fortuna
Serial No.: 09 909,488 Group Art Unit: 1723
Filed: July 20, 2001 Docket: 12897.10US01
Confirmation No.: 2586 Due Date: August 13, 2003
Title: NANOFILTRATION WATER-SOFTENING APPARATUS AND METHOD

CERTIFICATE UNDER 37 CFR 1.8:

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By: 
Name: Daniel Pauly

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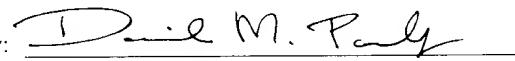
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DMP:ck



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S/N 09/909,488

PATENT

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By 
Name: Daniel Pauly

APPELLANT'S BRIEF ON APPEAL

Mail Stop Appeal Brief-Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Brief is presented in support of the Appeal filed February 13, 2003 from the final rejection of Claims 1-40 of the above-identified application, as set forth in the Office Action mailed October 22, 2002.

A check for \$320.00 to cover the required fee for filing this Brief is enclosed. An original and two copies of the Brief are enclosed herewith.

I. REAL PARTY OF INTEREST

This application is assigned to Cargill, Incorporated of Minneapolis, Minnesota.

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II. RELATED APPEALS AND INTERFERENCES

Appellants are unaware of any appeals or interferences that would directly affect or be directly affected by the outcome of the present appeal.

III. STATUS OF CLAIMS

Claims 1-40 are pending and are the subject of this Appeal (Appendix 1, Claims). The text of the claims on appeal is appended hereto.

IV. STATUS OF AMENDMENTS

No amendments were filed after the final Office Action mailed October 22, 2002.

V. SUMMARY OF THE INVENTION

The present invention is directed to apparatuses and methods for softening residential water, in particular to apparatuses and methods for efficiently softening water without the addition of ions to the wastewater stream, and more particularly to softening water at relatively low input water pressures. The apparatuses use at least one nanofiltration filter element to selectively remove hardness ions, in particular large ions (such as the divalent ions of calcium and magnesium). Thus, the apparatuses soften the water by removal of these ions, but do so without adding salt to the wastewater stream as is done with conventional water softeners.

The present invention is suitable for production of softened water with relatively low input pressure at sufficiently high flow rates in order to satisfy typical residential water needs. Water softeners made in accordance with the invention can produce suitable sustainable flow at a pressure of less than 200 pounds per square inch. Specific embodiments of the invention provide

an apparatus configured and arranged to have an output flow of permeate water of 200 gallons or more per 24-hour period. The softening apparatus is also generally highly efficient, and able to produce an output flow of permeate water containing greater than 80 percent of the input flow.

Also, in certain embodiments, the output flow of permeate water contains greater than 85 percent of the input flow, while in yet other embodiments the output flow of permeate water contains greater than 90 percent of the input flow without requiring high pressure inputs. Thus, the present invention allows highly favorable recovery rates of softened water while still having excellent softening properties. The output flow of permeate water can generally have, for example, a hardness below 3.5 grains per gallon. The present invention is well suited for use with potable water, and thus the input flow normally comprises potable water, such as that available from municipal water supplies or out of residential wells.

The nanofiltration filter element typically has an average pore size that permits the passage of water and most monovalent ions but substantially prevents the passage of most divalent ions. The apparatus is advantageously constructed such that it does not increase the total salt levels relative to the input flow of water. Thus, the softening apparatus does not add ions to the water stream, but rather removes at least some of the ions from the input flow and discharges them into the discarded non-permeate output flow. Various different nanofiltration filter elements are suitable for use with the invention, including filter elements that contain a positively charged membrane.

The present invention is also directed to methods of softening water. The methods generally include providing at least one nanofiltration filter element configured and arranged to receive an input flow of hard water, to discharge a first output flow of permeate water comprising a portion of the input flow and which has passed through the nanofiltration filter, and

to discharge a second output flow of non-permeate water comprising a portion of the input flow and which has not passed through the nanofiltration filter. The output flow of permeate water has a lower hardness than the output flow of non-permeate water.

VI. ISSUES PRESENTED FOR REVIEW

The issues raised in the final rejection of October 22, 2002 are: 1) the obviousness of claims 1-10, 12-25, 28-35, 37-40 over U.S. Patent No. 5,766,479 (Collentro et al.); 2) the obviousness of claims 1-10, 12-25, 28-35, 37-40 over U.S. Patent No. 5,234,583 (Cluff); and 3) the obviousness of claims 11, 12, 19, 26, 27, 36 over Collentro or Cluff in view of U.S. Patent No. 6,086,764 (Lunder et al.) and a *Chemical Engineering Progress* article (Ramen et al.) or U.S. Patent No. 5,147,553 (Waite).

VII. GROUPING OF CLAIMS

For the purposes of this appeal only, the claims are not considered to stand or fall together.

VIII. ARGUMENT

A. The Examiner has the burden to establish a *prima facie* case of obviousness.

Section 103 of Title 35 of the United States Code provides the test for obviousness under which the pending claims have been rejected:

A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to

a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

The Examiner has the burden of establishing a *prima facie* case for obviousness when rejecting an application under Section 103. *Ex parte Clapp*, 227 USPQ 972, 973 (Bd. Pat. App. & Inter. 1985).

Guidance on how to apply Section 103 is found in the Manual of Patent Examining Procedure (MPEP) Section 2143, which states that:

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

To support the conclusion that the claimed invention is directed to obvious subject matter, either the references must expressly or impliedly suggest the claimed invention or the examiner must present a convincing line of reasoning as to why the artisan would have found the claimed invention to have been obvious in light of the teachings of the references." *Ex parte Clapp* at 973. It is incumbent upon the Examiner to provide a reason why one of ordinary skill in the art would have been led to modify a prior art reference to arrive at the claimed invention. See *Ex parte Clapp* at 973. To this end, the requisite motivation must stem from some teaching, suggestion or inference in the prior art as a whole or from the knowledge generally available to one of ordinary skill in the art and not from appellants' own disclosure. See, for example, *Uniroyal, Inc. v. Rudkin-Wiley Corp.*, 5 USPQ2d 1434, 1439 (Fed. Cir. 1988).

If the Examiner fails to establish a *prima facie* case, the rejection is improper and will be overturned. See *In re Fine*, 5 USPQ2d 1596, 1600 (Fed. Cir. 1988). "Necessarily it is facts appearing in the record, rather than prior decisions in and of themselves, which must support the legal conclusion of obviousness under 35 U.S.C. § 103. Merely stating that a compound or composition is obvious, without adequate factual support, is not sufficient. *In re Cofer*, 148 USPQ 268, 271 (CCPA 1966).

B. The Examiner failed to establish a *prima facie* case of obviousness of the claims in view of Collentro.

1. The Examiner failed to identify any suggestion or motivation, either in Collentro itself or in the knowledge generally available to one of ordinary skill in the art, to modify Collentro to cover the claimed invention.

In rejecting the pending claims over Collentro, the Examiner has failed to provide any suggestion or motivation in Collentro to modify it to cover the pending claims.

Collentro is directed to an elaborate water purification system that utilizes repeat reverse osmosis steps along with pH adjustment to make ultrapure water for industrial applications. Nothing in Collentro is directed to softening water with a system having high ionic rejection rates, high water recovery rates, and low input pressures. Although Collentro discloses a pre-treatment step of softening water, it provides no suggestion that this pre-treatment step can be independently performed, and in particular provides no suggestion or motivation to modify this pre-treatment step to perform water softening with high ionic rejection rates, high water recovery rates, and low input pressures.

These aspects of the present invention are all quite important to the manufacture of a compact water-softening device without the need for high-pressure pumps or complex construction. The Examiner appears not to understand that the present application covers a

unique system selected to provide highly efficient small-scale water softening, even though this purpose is identified in the specification and embodied in the various claim limitations, particularly the ion rejection rates and the water recovery rates of the independent claims.

Collentro and the present application take entirely different approaches to very different problems, yet the Examiner fails to provide any substantive analysis connecting Collentro to the problems solved in the pending application. Thus, the Examiner has failed to identify any teachings or suggestions in Collentro to modify it for use according to the claimed invention, demonstrating the Examiner has not met her burden to establish a *prima facie* case for obviousness.

2. The Examiner has failed to demonstrate that one would have a reasonable expectation of success in modifying Collentro to cover the claimed invention.

The Examiner has also failed to make any showing of how the system of Collentro could be successfully modified to encompass the claims of the pending application. Collentro has no teaching of ion rejection rates greater than 80 percent or of water recovery rates greater than 80 percent, both of which are important aspects of the present invention and explicitly claimed in the pending independent claims. Collentro does not teach or suggest how these ionic rejection rates and water recovery rates can be accomplished, and does not provide any reasonable expectation of success at modifying Collentro to perform in accordance with the claimed invention. In addition, the various dependent claims of the pending application further distinguish over Collentro, resulting in an improved softening effect not taught by Collentro. These claims, such as claims 5 and 6 of the pending application, teach even higher levels of ion rejection than the independent claims, and are a further inventive distinction over the prior art.

The Examiner provides arguments that it would be obvious to one of skill in the art to make such changes, but in doing so the Examiner provides no support for why such changes would be successful. The Examiner has sought to make numerous "obvious" expansions in the prior art without identifying how such expansions can be made without diverging from the reference or without making an inoperable apparatus. In particular, she fails to explain how the prior art Collentro reference can be modified on one term (such as flow rates) without changing ion rejection rates. In this manner the Examiner has deviated from the teachings of Collentro and has impermissibly expanded Collentro without consideration for the likelihood of making a working apparatus.

This failure to provide a basis for showing a reasonable likelihood of success in modifying Collentro is further grounds for overturning the obviousness rejection.

3. The Examiner has failed to show how Collentro teaches or suggests all the claim limitations.

Not only has the Examiner failed in the first two steps required to support a *prima facie* obviousness rejection, but the Examiner has also failed to show how Collentro teaches or suggests all of the claim limitations of the pending patent application. Indeed, at least two fundamental limitations of the claims are not taught or suggested by Collentro.

First, Collentro teaches that the membrane in its pretreatment step removes only "up to about 80 percent" of large ionic radius radicals. (*See column 6, lines 14, 15*). This removal level of large ionic radius radicals is generally inadequate for residential water softening systems as taught by Applicants, particularly in areas with high hardness, because the softening effect would be inadequate. In contrast, all pending claims of the present application require removal

of at least 80 percent of large ionic radius radicals, and some claims are more narrowly drawn, requiring at least 85 percent or at least 90 percent removal.

The Examiner ignores these claim limitations, stating merely that column 6, lines 3-29 of Collentro discloses the claimed rejection rates. Review of Collentro demonstrates that the Examiner is incorrect. Collentro merely discloses a rejection rate of "up to about 80%" of large ionic radius ions. This rejection rate is below the "at least 80 percent" rejection rates of the independent claims of the pending application, and unequivocally below the higher rates of 85 and 90 percent rejection rates of dependent claims. Surprisingly, the Examiner provides no discussion of these higher rejection rates, merely ignoring the limitations and broadly stating that they would be obvious in view of the silent Collentro reference.

In addition, the Examiner has failed to show how Collentro teaches a system in which at least 80 percent of input water is recovered. Here, too, Collentro is silent as to water recovery rates, and the Examiner readily acknowledged that Collentro fails to teach an appreciation for the need for high water recovery rates (which provides efficient recovery with minimal wasted water). The Examiner stated in the Final Office Action that the amount of water flow is not expressly disclosed in Collentro, and merely states in the that "it would have been obvious to one skilled in the art at the time the invention was made to use multiple membranes in the water softening apparatus of Collentro to achieve a predetermined desired permeate flow." The Examiner provides *absolutely no support for this position*, and thus utterly fails to establish a *prima facie* case of obviousness. As a matter of law, this unsupported statement is inadequate for forming a basis for an obviousness rejection because, for example, the Examiner provides no underlying support as to why such a plurality of membranes would be functional as claimed by Appellants, provides no rationale for why such multiple membranes would not interfere with the

ion recovery rates, and provides no reasoning why they would operate under the claimed flow pressures.

The Examiner's failure to adequately show that each limitation of the pending claims is taught or suggested by the prior art further demonstrates a failure to establish a *prima facie* case of obviousness, and the rejection should accordingly be reversed.

C. The Examiner has failed to establish a *prima facie* case of obviousness of the claims in view of the pool filtering system of Cluff.

The Examiner has also asserted that the water softening system of the present invention is obvious in view of the pool-filtering patent of Cluff. Here, too, the Examiner has failed on each of the requirements for establishing a *prima facie* case of obviousness.

1. The Examiner failed to identify any suggestion or motivation, either in Cluff itself or in the knowledge generally available to one of ordinary skill in the art, to modify Cluff to cover the claimed invention.

The record contains no suggestion or motivation to modify Cluff to cover the claimed invention. The pool filtering system of Cluff is non-analogous art to that of water softening. When a reference is not directed to the same purpose as an application, there is less motivation to apply that reference and less reason to apply that reference for an obviousness determination. "[It] is necessary to consider 'the reality of the circumstances', . . . - in other words, common sense - in deciding in which fields a person of ordinary skill would reasonably be expected to look for a solution to the problem facing the inventor. . . . The combination of elements from non-analogous sources, in a manner that reconstructs the applicant's invention only with the benefit of hindsight, is insufficient to present a *prima facie* case of obviousness." *Pentec, Inc. v. Graphic Controls Corp.*, 976 F.2d 436, 230 USPQ 3113 (Fed. Cir. 1986).

Applicants believe one of skill in the art of making water softeners would not look to pool filters for a water softening solution. Pool filters do not soften water by removing soluble ions, but rather filter out larger contaminants that are retained in the filter. Indeed, the system of Cluff draws input water from a pool and then subsequently discharges the same water back into the pool, resulting in minimal softening of the entire water stream due to the cycling water flow through the pool. Applicants believe the failure of Cluff to be drawn to an analogous art as water softening to be sufficient to make Cluff inappropriate as the basis for an obviousness rejection.

In addition, even if pool filtering equipment is regarded as adequately analogous to water softening equipment to apply Cluff to the pending claims, there is still absolutely no suggestion or motivation in Cluff to modify it to be used as a water softener. Nothing in Cluff teaches the need to remove hardness ions from the water, nothing in Cluff is directed toward treatment of potable water, nothing in Cluff is directed toward low pressure treatment of water, nothing in Cluff emphasizes having high ionic rejection rates, and nothing in Cluff is directed to the need for high water recovery rates. Simply put, Cluff neither teaches the problem identified in the present application, nor does it teach a solution to that problem, and therefore it cannot serve as a *prima facie* obviousness rejection.

2. The Examiner has failed to demonstrate that one would have a reasonable expectation of success in modifying Cluff.

The Examiner has also failed to provide any *prima facie* support to establish a suggestion of a reasonable expectation of success in modifying Cluff. Both the suggestion and the reasonable expectation of success must be founded in the prior art, not in the applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

Rather than finding a suggestion for success in modifying Cluff, the Examiner merely dismisses one limitation after another as being obvious, even while acknowledging that the

limitations are not disclosed in Cluff. The Examiner has essentially taken a view that each and every aspect of the Cluff disclosure can be freely expanded, contracted, or modified to find the claims obvious. This liberal expansion of Cluff is impermissible as a matter of law without a reasonable expectation of success, which does not exist in the present case.

Indeed, Cluff actually teaches the concept that selective rejection of ions is a matter depending upon multiple factors. See Cluff at column 1, lines 38 to 40. In this regard, Cluff teaches that filtration is a complicated, multi-factor process, thereby making any modification in the system less obvious. Modification of one aspect of the filter system, such as an increase in the number of filter elements, is likely to require a simultaneous modification in another aspect of the filter system, such as input pressures. Similarly, increases in ion retention are likely to lead to a concurrent diminishment in water recovery rates. The Examiner does not appear to have understood that her efforts to expand the teachings of Cluff in so many aspects are unsupported by Cluff itself, and thus impermissible. Nevertheless, the lack of a reasonable expectation of success defeats any *prima facie* case of obviousness.

3. The Examiner has failed to show how Cluff teaches or suggests all the claim limitations.

Even if Cluff is applied to the present invention, it provides no teaching or suggestion as to various elements of the claimed invention, and the Examiner has failed in her burden to show that all such elements are obvious. Most notably, the Examiner's rejection in view of Cluff simply fails to address the issue of water recovery rates. The final office action of October 22, 2002 does not even mention elements b) and c) of claim 1, which requires that the output flow of permeate water be at least 80 percent of the input flow, and the output flow of non-permeate water be less than 20 percent of the input flow. The Examiner discusses "flow" only in the

context of absolute water softening levels (which involves rates of production of softened water), not the flow rate as a percentage of recovery (which involves efficiency).

This obviousness rejection that does not even consider all of the claim limitations is impermissible under any interpretation of Section 103, and therefore the Examiner has failed to satisfy her obligation to establish a *prima facie* case of obviousness.

D. The Examiner has failed to establish a *prima facie* case of obviousness of the claims in view of Collentro or Cluff in view of Linder and Raman or Waite.

The Examiner has also further rejected claims 11, 12, 19, 26, 27, and 6 over Collentro or Cluff in view of Linder et al. (6,080,764), Waite (5,147,553), or Ramen (*Chemical Engineering Progress* article).

Even if the Examiner has shown in the prior art relied upon that certain individual features of the claimed subject matter may be known, such a showing alone cannot support a rejection under 35 U.S.C. § 103. Knowledge of separate features is not the appropriate test for obviousness under Section 103. Rather, the proper test for obviousness is whether the claimed subject matter taken as a whole, in light of all of the teachings of the references in their entireties, would have been obvious to one of ordinary skill in the art at the time the invention was made.

See Connell v. Sears Roebuck Co., 722 F.2d 1542, 1549, 220 USPQ 193, 199 (Fed. Cir. 1983).

Moreover, even if we assume the mere fact that the applied references *could* be combined or expanded in a manner which might result in the claimed subject matter, this does not make the proposed modification obvious unless the references fairly suggest the desirability of the modification or expansion. *See In re Gordon*, 733 F.2d 902, 221 USPQ 1125, 1127 (Fed. Cir. 1984).

Linder is directed to specialized membranes that are acid- and base-resistant and which also are amphoteric. Nothing in Linder teaches or suggests the claimed invention. Indeed, Linder actually teaches the non-obvious nature of the present invention by asserting that the "[nanofiltration] membrane chosen depends upon the application". Column 3, lines 41-42. This statement, along with the accompanying text at column 3, lines 27-42 which identifies the variety of membranes available, is an acknowledgement that nanofiltration membranes are not all equivalent, nor is their performance readily predictable between applications.

Waite fails to teach the claimed invention even when combined with the previously discussed references, and in particular fails to teach or make obvious an apparatus that is configured to reject at least 80 percent of calcium ions and discharge an output flow of permeate water comprising at least 80 percent of the input flow.

Ramen provides broad, general information about uses for nanofiltration technology, but in no way suggests or makes obvious the claimed invention.

In the present case, the dissimilar objectives of the applied references, coupled with the lack of an incentive in the references themselves for making the modifications proposed by the Examiner, leads to the conclusion that the rejection is not well founded. When we consider the teachings of the applied references together, forgetting about what Applicants have taught in the present application, it becomes clear that without Applicants' teachings, the references themselves would not have fairly motivated the person of ordinary skill in the art to make the claimed invention.

The Examiner has expanded the cited references to cover the claimed invention without providing adequate support as to why such expansion is appropriate. It is improper to make this factual-based determination upon subjective belief and unknown authority. *W.L. Gore v.*

Garlock, Inc., 721 F.2d 1540, 1553, 220 USPQ 303, 312-13 (Fed. Cir. 1983). Applicants respectfully assert that the Examiner has failed to make a *prima facie* case of obviousness.

SUMMARY

The Examiner has failed to support her burden of establishing a *prima facie* case of obviousness over the references of record. She has not shown suggestions or teachings to modify the references, has not shown why such modifications would have been likely to be successful, and has not shown that all the limitations of the claims are obvious. Therefore, the obviousness rejections are untenable and should be reversed.

Respectfully submitted,

Muralidhara et al.

By their Attorneys,

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Date: August 13, 2003



A handwritten signature in black ink, appearing to read "Daniel M. Pauly".

Daniel M. Pauly
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APPENDIX I
THE CLAIMS ON APPEAL

1. An apparatus for softening water, the apparatus comprising:
 - at least one nanofiltration filter element configured to reject at least 80 percent of calcium ions, and configured to:
 - a) receive an input flow of hard water,
 - b) discharge an output flow of permeate water comprising at least 80 percent of the input flow, and
 - c) discharge an output flow of non-permeate water comprising less than 20 percent of the input flow;wherein the output flow of permeate water has a lower hardness than the output flow of non-permeate water.
2. The apparatus for softening water of claim 1, wherein the nanofiltration element is configured to receive an input flow of hard water at a pressure below 250 psi.
3. The apparatus for softening water of claim 1, wherein the nanofiltration element has a molecular weight cut-off of 20 to 500.
4. The apparatus for softening water of claim 1, wherein the water flux through the nanofiltration element is at least 75 liters per square meter per hour.

5. The apparatus for softening water of claim 1, wherein the nanofiltration element has a calcium ion rejection rate greater than 85 percent.

6. The apparatus for softening water of claim 1, wherein the nanofiltration element has a calcium ion rejection rate greater than 90 percent.

7. The apparatus for softening water of claim 1, wherein the nanofiltration element is configured to discharge an output flow of permeate water comprising at least 90 percent of the input flow.

8. The apparatus for softening water of claim 1, wherein the peak output flow rate of permeate water is less than 10 gallons per minute.

9. The apparatus for softening water of claim 1, wherein the nanofiltration filter element has an average pore size that permits the passage of water and monovalent ions but substantially prevents the passage of divalent ions.

10. The apparatus for softening water in accordance with claim 1, wherein the apparatus does not substantially increase the total salt levels of the output flows relative to the input flow of water.

11. The apparatus for softening water in accordance with claim 1, wherein the nanofiltration filter element comprises a positively charged membrane.

12. The apparatus for softening water in accordance with claim 1, wherein the input flow comprises potable water.
13. The apparatus for softening water in accordance with claim 1, wherein the output flow of permeate water has a hardness below 3.5 grains per gallon.
14. The apparatus for softening water in accordance with claim 1, wherein the apparatus is configured and arranged to have an output flow of permeate water of 200 gallons or more per 24-hour period.
15. Water softened using the apparatus of claim 1.
16. An apparatus for softening water, the apparatus comprising:
 - a) receive an input flow of hard water,
 - b) discharge an output flow of permeate water comprising at least 90 percent of the input flow, and
 - c) discharge an output flow of non-permeate water comprising less than 10 percent of the input flow;

wherein the output flow of permeate water has a lower hardness than the output flow of non-permeate water.

17. The apparatus for softening water of claim 16, comprising one nanofiltration element.
18. The apparatus for softening water of claim 16, comprising two or more nanofiltration elements.
19. The apparatus for softening water of claim 16, wherein the nanofiltration element has a rejection rate of greater than 90 percent.
20. The apparatus for softening water of claim 16, wherein the apparatus has a water recovery rate of at least 90 percent.
21. The apparatus for softening water of claim 16, wherein the peak flow rate is from 5 to 10 gallons per minute.
22. The apparatus for softening water of claim 16, wherein the nanofiltration element has a molecular weight cut-off of 20 to 500.
23. The apparatus for softening water of claim 16, wherein the nanofiltration filter element has an average pore size that permits the passage of water and monovalent ions but substantially prevents the passage of divalent ions.

24. The apparatus for softening water in accordance with claim 16, wherein the apparatus does not substantially increase the total salt levels relative to the input flow of water.

25. The apparatus for softening water in accordance with claim 16, wherein the input flow is provided at a pressure of less than 200 pounds per square inch.

26. The apparatus for softening water in accordance with claim 16, wherein the nanofiltration filter element comprises a positively charged membrane.

27. The apparatus for softening water in accordance with claim 16, wherein the input flow comprises potable water.

28. The apparatus for softening water in accordance with claim 16, wherein the output flow of permeate water has a hardness below 3.5 grains per gallon.

29. The apparatus for softening water in accordance with claim 16, wherein the apparatus is configured and arranged to have an output flow of permeate water of 200 gallons or more per 24 hour period.

30. Water softened using the apparatus of claim 16.

31. A method for softening water, the method comprising:

providing at least one nanofiltration filter element configured to reject at least 80 percent of calcium ions;

receiving an input flow of water having at least 2 grains of hardness per gallon;

discharging a first output flow of permeate water comprising at least 80 percent of the input flow, and which has passed through the nanofiltration filter; and

discharging a second output flow of non-permeate water comprising less than 20 percent of the input flow, and which has not passed through the nanofiltration filter;

wherein the output flow of permeate water has a lower hardness than the output flow of non-permeate water.

32. The method for softening water of claim 31, wherein the nanofiltration filter element has an average pore size that substantially permits the passage of water and monovalent ions but substantially prevents the passage of divalent ions.

33. The method for softening water in accordance with claim 31, wherein the method does not substantially increase the total salt levels of the output flows relative to the input flow of water.

34. The method for softening water in accordance with claim 31, wherein the input flow is provided at a pressure of less than 200 pounds per square inch.

35. The method for softening water in accordance with claim 31, wherein the input flow is provided at a pressure of 140 to 200 pounds per square inch.

36. The method for softening water in accordance with claim 31, wherein the nanofiltration filter element comprises a positively charged membrane.
37. The method for softening water in accordance with claim 31, wherein the output flow of permeate water contains greater than 90 percent of the input flow.
38. The method for softening water in accordance with claim 31, wherein the output flow of permeate water has a hardness below 3.5 grains per gallon.
39. The method for softening water in accordance with claim 31, wherein the method is configured and arranged to have an output stream of permeate water of 200 gallons or more per 24 hour period.
40. Water softened using the method of claim 31.

